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Uncertainty in catch and effort data of small- and medium-scale tuna fisheries in Indonesia: Sources, operational causes and magnitude



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ABSTRACT

This study aims to identify the sources and magnitude of uncertainty in the collection and processing of catch and effort data of small- and medium-scale tuna fisheries in Indonesia, as well as the causes of uncertainty on an operational level. We identified possible sources of uncertainty through a literature review and interviews with experts. Next, we surveyed 40 small-scale (< 10 GT) and medium-scale (10–100 GT) pole-and-line, purse-seine, longline and handline fishers in the oceanic fishing port Bitung, which has the largest number of tuna fisheries activities in eastern Indonesia, to estimate the magnitude of unreported catch of juvenile tuna, on-board consumption, home consumption and catch used as bait. We used logbook data from the fisheries submitted to the fishing port authorities to extrapolate survey results to the fishing port level. Uncertainties around unreported catches were due both to non-reporting by fishers to the fishing port authority and to flaws in data management in the data collection institution. After removing flaws in the logbook database we estimated that the catch by small- and medium-scale fishing vessels active in Indonesian waters could be about 33–38% higher than reported. The proportion of unreported catch, as well as the sources and range of uncertainty, varied according to the types of gear used. Finally, we discuss what aspects of data collection and processing should be improved at the fishing port level, including the identified sources of unreported catch and the processes leading to non-reporting. We hence provide a methodology for estimating unreported catches in small and medium-scale fisheries.

1. Introduction

Globally, fisheries catch statistics underestimate actual catch (Pauly and Zeller, 2016; Watson and Pauly, 2001). Pauly and Zeller (2016) estimate that global catch between 1950 and 2010 might be 50% higher than that reported by member countries to the Food and Aquaculture Organisation of the United Nations (FAO). Worldwide, total unaccounted for catches from unregistered illegal and unreported fishing during 1980–2003 were estimated between 11 and 26 million tonnes or about \$10bn–\$23.5bn annually (Agnew et al., 2009). Catch underestimation is a major cause of uncertainty in estimates of fishing mortality, stock size, and ecosystem impacts from fishing (Caddy and Mahon, 1995; Patterson et al., 2001). For example, the Commission for the Conservation of Southern Bluefin Tuna (CCSBT) redefined its management procedure after accounting for the uncertainty associated with its data induced by misreporting and taking account of illegal, unreported and unregulated (IUU) catches (Kurota et al., 2010;

Polacheck, 2012).

The reasons for the underestimation of catches include inadequate data collection systems (Belhabib et al., 2014; Crego-Prieto et al., 2012; Lescauwae et al., 2013), illegal fishing (Agnew et al., 2009; Pitcher et al., 2002; Polacheck, 2012; Worm et al., 2009), unreported discards (Patterson et al., 2001; Zeller and Pauly, 2005), and unreported landings by fishers (Bailey et al., 2015; Watson and Pauly, 2001). Another cause is that fisheries managers pay limited attention to small-scale fisheries (Béné et al., 2010; Gillet, 2011; Pauly, 2006; Zeller et al., 2014), which are often found in areas that are difficult to access (Pauly, 1997) and require substantial financial, technical and human capabilities and resources to gather data on (Zeller et al., 2014).

The problem of catch and effort underestimation is particularly urgent in Indonesia. Previous studies (Dudley and Harris, 1987; Proctor et al., 2003) found that Indonesia's national fisheries data suffer from inadequacies, many of which have already been identified in an early FAO report by Yamamoto (1980). Despite major changes to the data

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collection system in response to this report, many of the problems of catch underestimation have persisted. In 1995, a logbook system was introduced to a tuna longline fishery in Muara Baru, Jakarta (Proctor et al., 2003). This effort was strengthened in 2002 with the Decision of the Minister of Marine Affairs and Fisheries Number 3 and again in 2010 with the Regulation of the Minister of Marine Affairs and Fisheries Number 18. However, data reconstructions suggest that the Indonesian catch between 1950 and 2010 was 38% higher than what was reported to the FAO.¹

As in other fishing nations, catch underestimation in Indonesian data is driven by a range of factors. These include illegal and unreported catch, and procedural problems in primary data collection through the use of logbooks (Bailey et al., 2012; Mous et al., 2005; Pramod et al., 2014; Proctor et al., 2003; Varkey et al., 2010). Varkey et al. (2010) estimate that approximately 13,000 t of tuna caught in Raja Ampat in 2006 was not reported, an amount equivalent to 75% of the reported catch from the area in that year. Pramod et al. (2014) estimate that 35% of tuna exported to the USA in 2011 from the Philippines, Vietnam and Indonesia was caught illegally. They also indicate that 25% of the tuna catch exported by Vietnam was caught illegally from the Indonesian Exclusive Economic Zone (EEZ). Misreporting is a rampant source of uncertainty: differences between reported and actual landed catch are often caused by stratification of catch categories not based on species, but rather on what is useful for trade and sale.² This leads to misreporting when different species with the same price category are recorded as one species.

These problems are also found in eastern Indonesia where catch reconstructions over the period from 1950 to 2010 estimate that the total catch was around 57% higher than what was reported.¹ This estimate, however, is based at the provincial level for all categories of IUU fishing in nine major taxonomic categories, and does not distinguish among fisheries or drivers of catch underestimation in official statistics. Tuna fisheries in eastern Indonesia are the largest contributor to the total tuna catch of Indonesia. Gillet (2011) finds that one of the drivers of the low quality of national tuna fisheries statistics is the underreporting of tuna catches in eastern Indonesia, particularly by small-scale fisheries. These uncertainties are usually attributed to flaws at the level of primary data collection, i.e., in the first observation of quantities (Dame and Christian, 2006; Punt et al., 2016; Rosenberg and Restrepo, 1994). However, it has not yet been further specified how these flaws originate in the process of data collection at the level of individual fishers and data collectors, and how this relates to their understanding of the systems in place. Limited attention has also been given to uncertainties as a result of flaws in the processing of primary data into databases.

The Indonesian Ministry of Marine Affairs and Fisheries (MMAF) is currently improving its data collection system in view of the demands from the three Regional Fishery Management Organisations (RFMOs): the aforementioned CCSBT, the Indian Ocean Tuna Commission (IOTC), and the Western and Central Pacific Fisheries Commission (WCPFC). The WCPFC collaborates with the MMAF to strengthen Indonesian tuna data collection through such initiatives as the West Pacific East Asia-Oceanic Fisheries Management (WPEA-OFM) program in eastern Indonesia (WCPFC, 2007). In a 2013 catch estimates workshop, the WCPFC recommended that the MMAF identify the causes of uncertainty in catch and effort estimates and find solutions to address the inaccuracies in its data (WCPFC, 2013).

This article aims to identify and quantify the sources of uncertainty

¹ Pauly, D., Budimartono, V. (2015) Marine Fisheries Catches of Western, Central and Eastern Indonesia, 1950–2010. Fisheries Centre Working Paper #2015-61. <http://www.seararoundus.org/doc/publications/wp/2015/Pauly-and-Budimartono-Indonesia.pdf>

² Pet-Soede, C. and Ingles, J. (2008) Getting Off the Hook: Reforming the Tuna Fisheries of Indonesia & Considerations for Ecosystem-based Management. Worldwide Fund for Nature. <http://wwf.panda.org/?150401%2FGetting-Off-the-Hook-Reforming-the-Tuna-Fisheries-of-Indonesia-Considerations-for-Ecosystem-based-Management>

in catch and effort data of the small and medium-scale tuna fisheries in Indonesia, exemplified by the oceanic fishing port (OFP) Bitung in North Sulawesi. Small-scale fishers are those who work without a vessel, or with a vessel of maximum 10 gross tonnage (GT) (Law of Indonesia No. 7/2016). Medium-scale fishers are commercially oriented, and use vessels between 11 and 100 GT. We aim to 1) identify the causes of errors in the process of data reporting by small-scale and medium-scale fishers to the authority in OFP Bitung; and 2) to quantify the major sources of catch underreporting besides illegal fishing. In addition we report on problems we encountered in the data processing phase of our study. Our research questions for this study are: 1) What are the main sources of uncertainty in catch and effort data of the tuna fisheries in Indonesia?; 2) What are the causes of these uncertainties at the operational level?; and 3) What is the impact of the main sources of uncertainty on the catch reporting of the small and medium fisheries in the OFP Bitung? We addressed these questions through interviews with fisheries data collection and assessment experts, a survey among fishers in the OFP Bitung, and by extrapolating our findings to the level of the fishing port by means of logbook data. Although it is not the explicit focus of our research, we also report on and discuss problems that we encountered during the data processing phase of our research.

2. Materials and methods

2.1. Study site

In 2012 and 2013, tuna production in the province of North Sulawesi amounted to 22% of the estimated total catch of yellowfin tuna (*Thunnus albacares*) and 14–23% of bigeye tuna (*Thunnus obesus*) in Indonesia (DGCF-MMAF, 2013, 2014). The largest producer is the OFP Bitung which, in addition to a large-scale fishery, harbours numerous small-scale and medium-scale tuna fisheries, and is therefore a sensible location to investigate uncertainty in catch and effort data of fisheries of this size.

2.2. Data collection

Fig. 1 shows the flowchart of data collection, data harmonisation, and data analysis. We collected data through a literature review, expert interviews, a field survey among fishers, and database analysis of logbook and permit issuance data provided by the OFP Bitung. Fishing vessels need a permit every time they leave OFP Bitung, the issuance of which involves a registration of the previous return to the port and the vessel's date of departure. This database also includes such attributes as gross tonnage and gear used for every reported trip. The aim of the field survey was to estimate the magnitude of the main sources of uncertainty in catch estimates, and the logbook data were used to extrapolate the survey results to port level. The permit issuance data were used to complement missing effort information in the logbook data.

2.2.1. Literature review and interviews

Sources for our literature review include primary publications as well as reports from tuna RFMOs and relevant fisheries research institutions. We focused our review on articles and reports that identify sources of uncertainty in recorded catch data. Interviews were conducted with fisheries officers of the MMAF in Jakarta and Bitung and with fishers, data collectors, observers, and surveillance officers in Bitung (see Supplementary Appendix 1 in the online version at DOI: <http://dx.doi.org/10.1016/j.fishres.2017.04.009> for a list of respondents). Respondents were selected who had a role in the data collection process and/or were knowledgeable about catch and effort data collection problems in Indonesia. The selection of respondents was a combination of purposive and snow-ball methods, as we were interested to interview respondents with a particular expertise and to gain richer insights into the sources of uncertainty identified in the

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